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Effect of Elevated CO_2 on CH_4 Emission from Rice Fields

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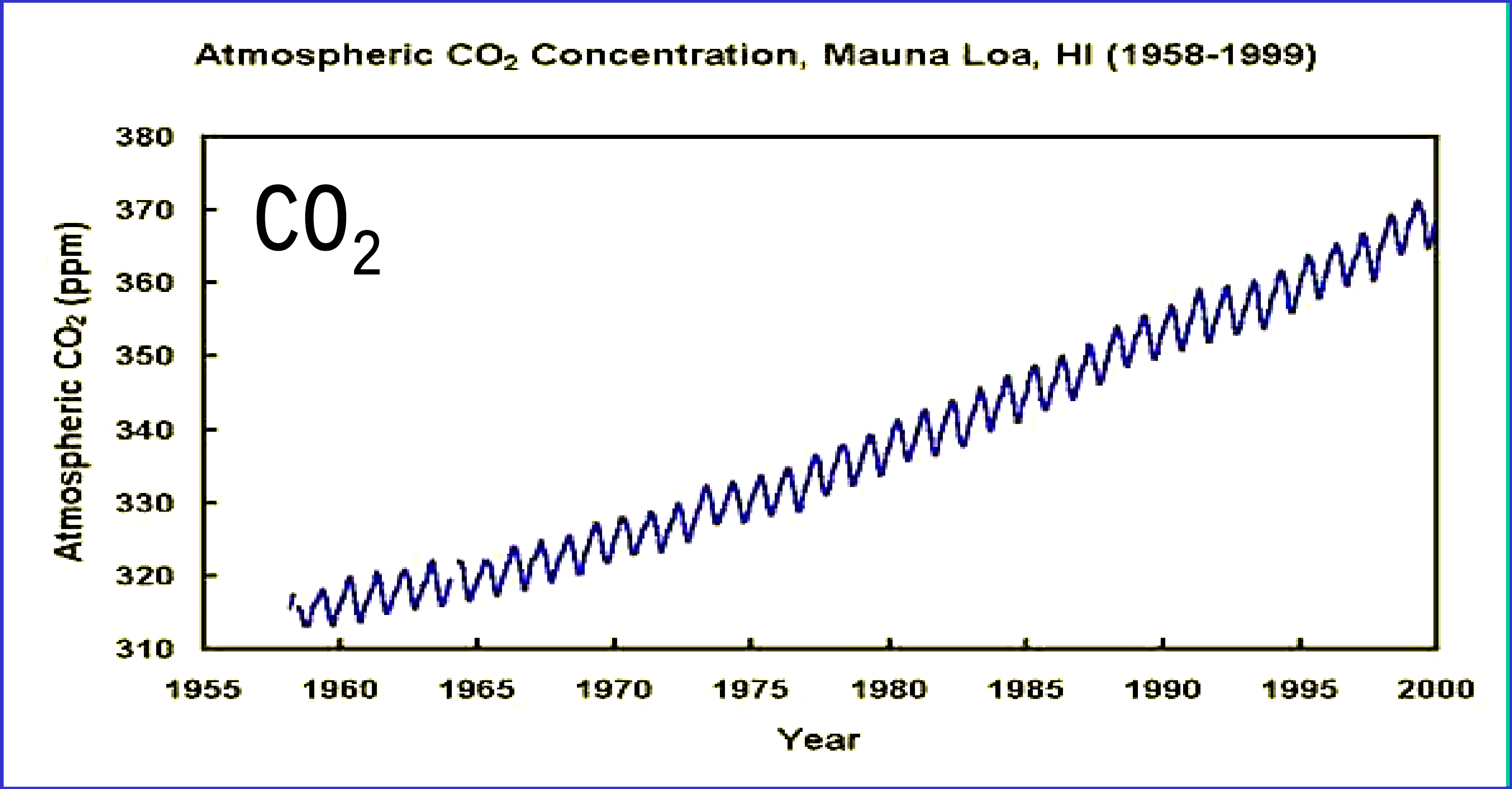
How elevated CO_2 impacts GHGs exchanges over natural or managed terrestrial ecosystems?



FACE (Free Air CO_2 Enrichment) experiments have been designed and launched to investigate the effects of elevated CO_2 on ecological processes and exchanges of trace gases.

Direct Objectives of FACE Study on Exchange of Trace Gases

Annual net flux under FACE

Standard error of annual net flux under FACE

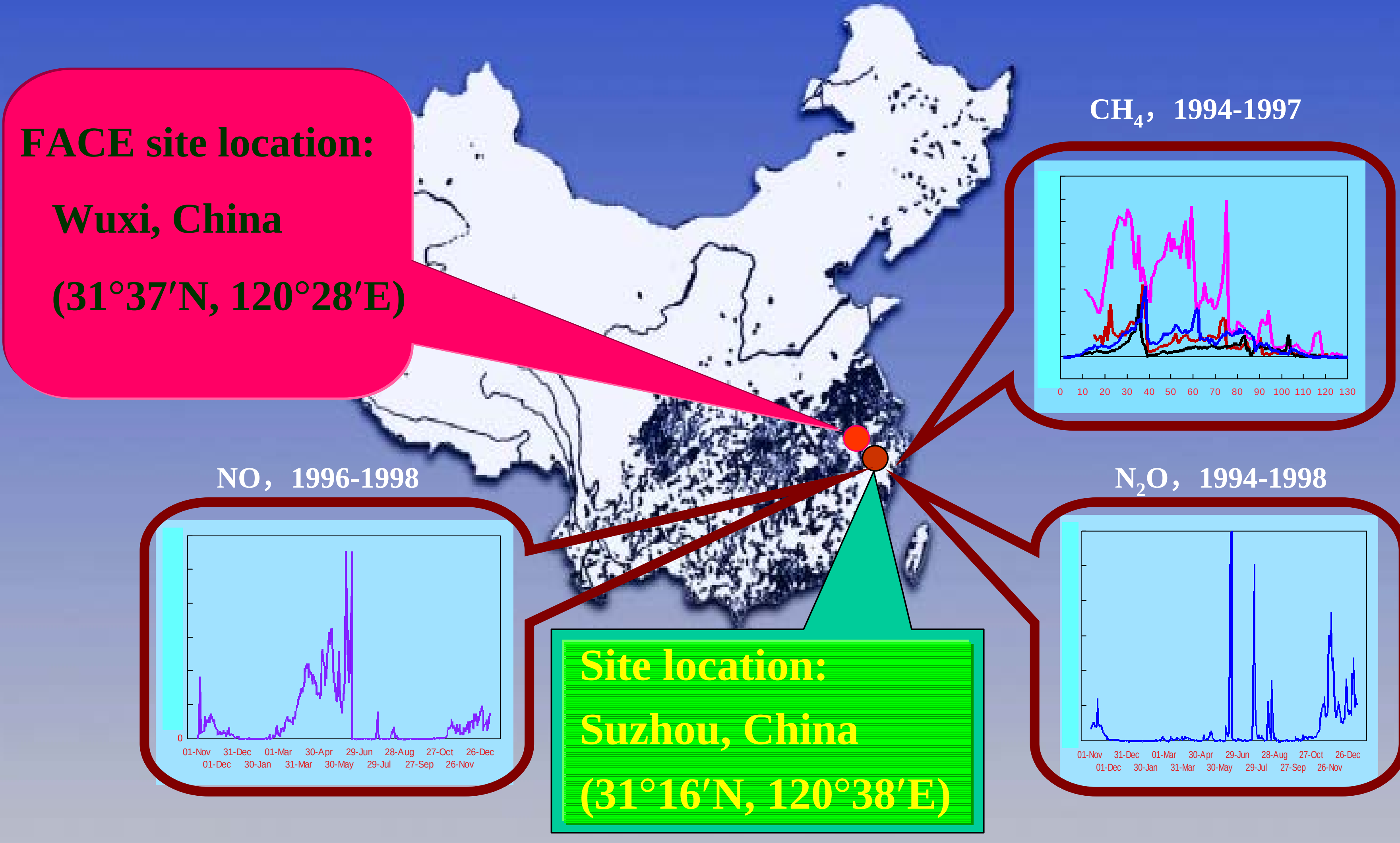
$$(F_s \pm \varepsilon_{F_s}) - (A_s \pm \varepsilon_{A_s}) \begin{cases} > 0 & \text{Positive effect} \\ < 0 & \text{Negative effect} \\ \approx 0 & \text{No effect} \end{cases}$$

Standard error of annual net flux under AMBIENT

Annual net flux under AMBIENT

$S \in \{CH_4, CO_2, N_2O, NO, CO\}$

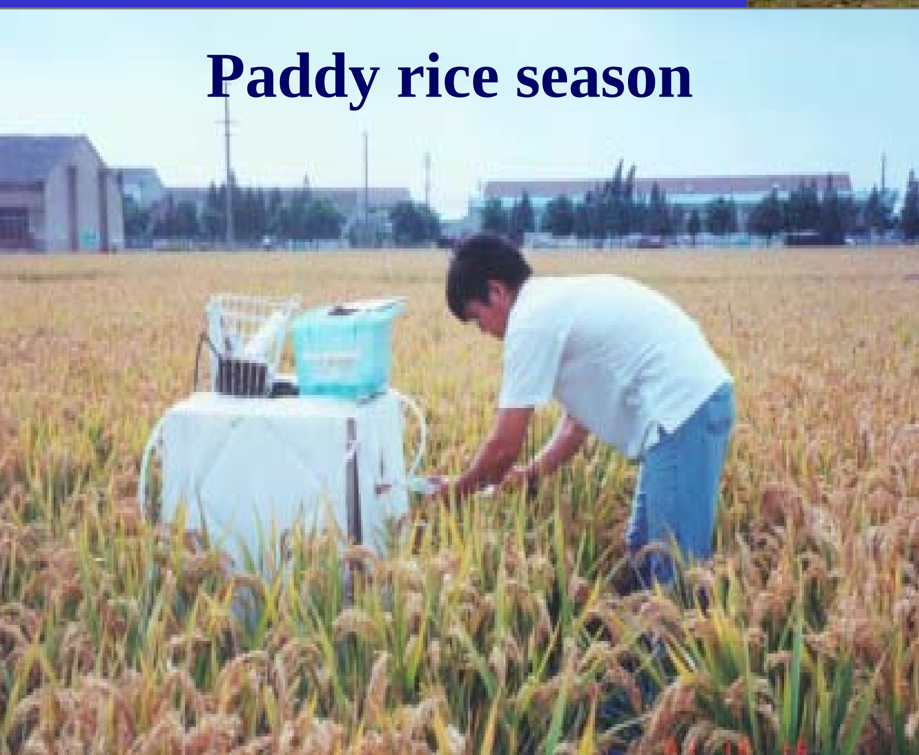
The location of FACE site at Wuxi and a former trace gas observation site at Suzhou



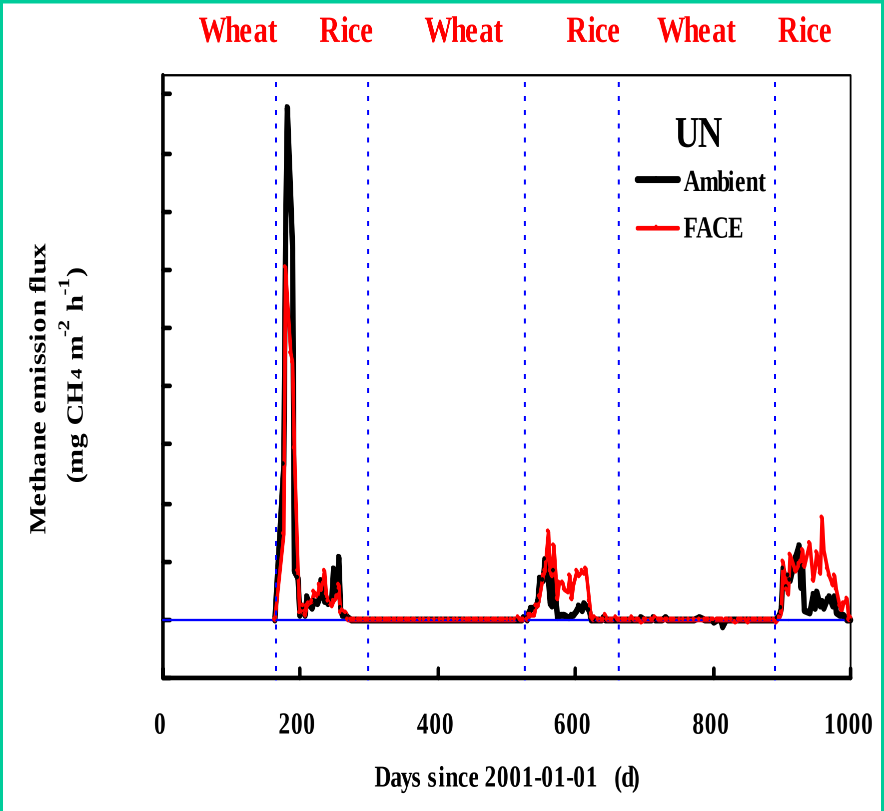
Field treatments of CO_2 and N amendment

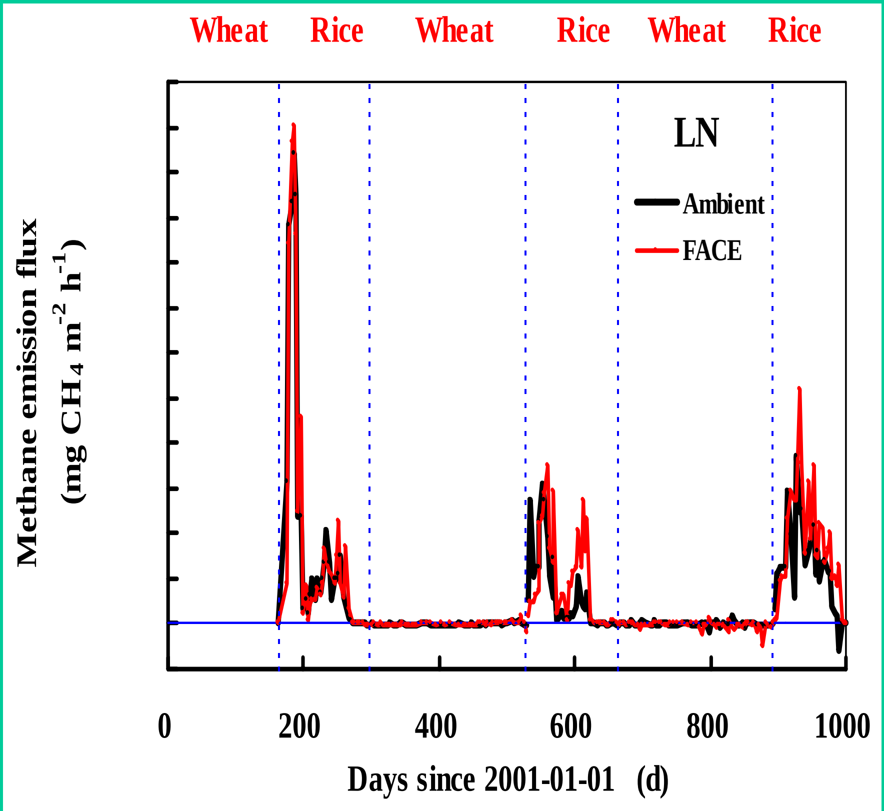
CO_2 (ppmv)	N rate (N ha^{-1})	Replicates
FACE: A + 200	300	3 (FACE-LN)
	500	5 (FACE-UN)
Ambient: A	300	3 (Ambient-LN)
	500	5 (Ambient -UN)

Field *in situ* measurement of emissions of trace gases



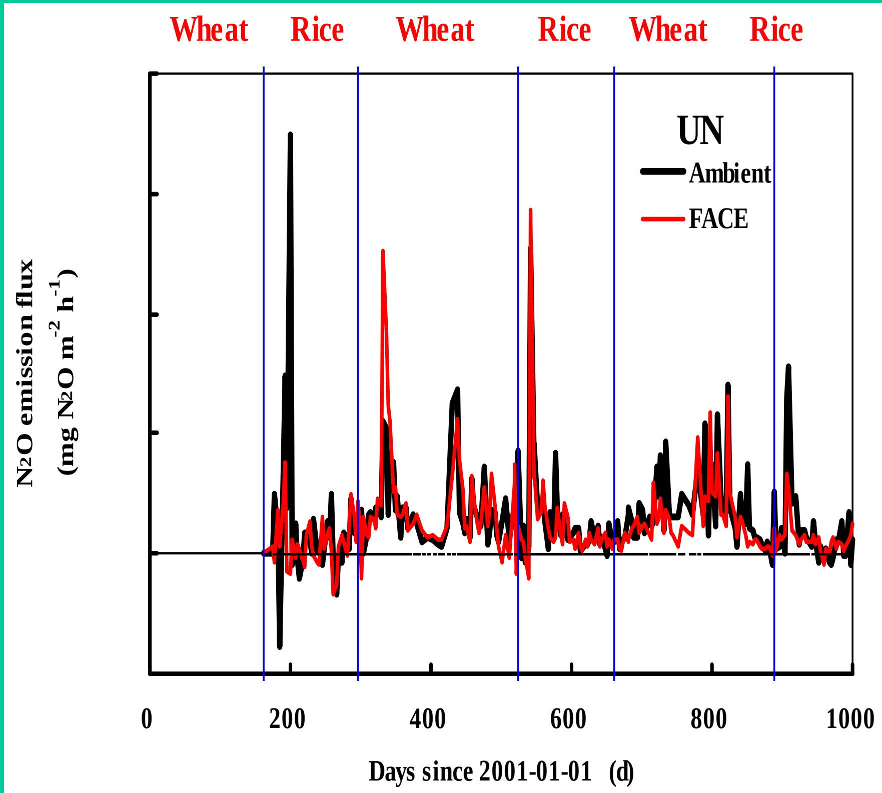
CH_4 emission

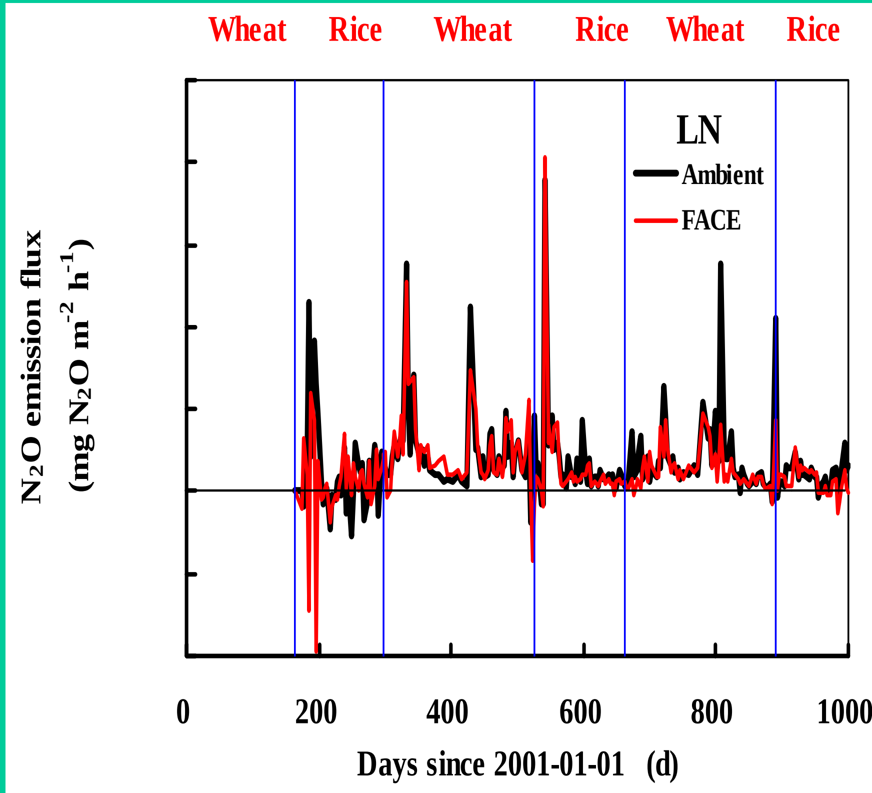




Observed CH_4 emission fluxes from rice-wheat rotation fields （2001. 6. 25 ~ 2003. 9. 29）

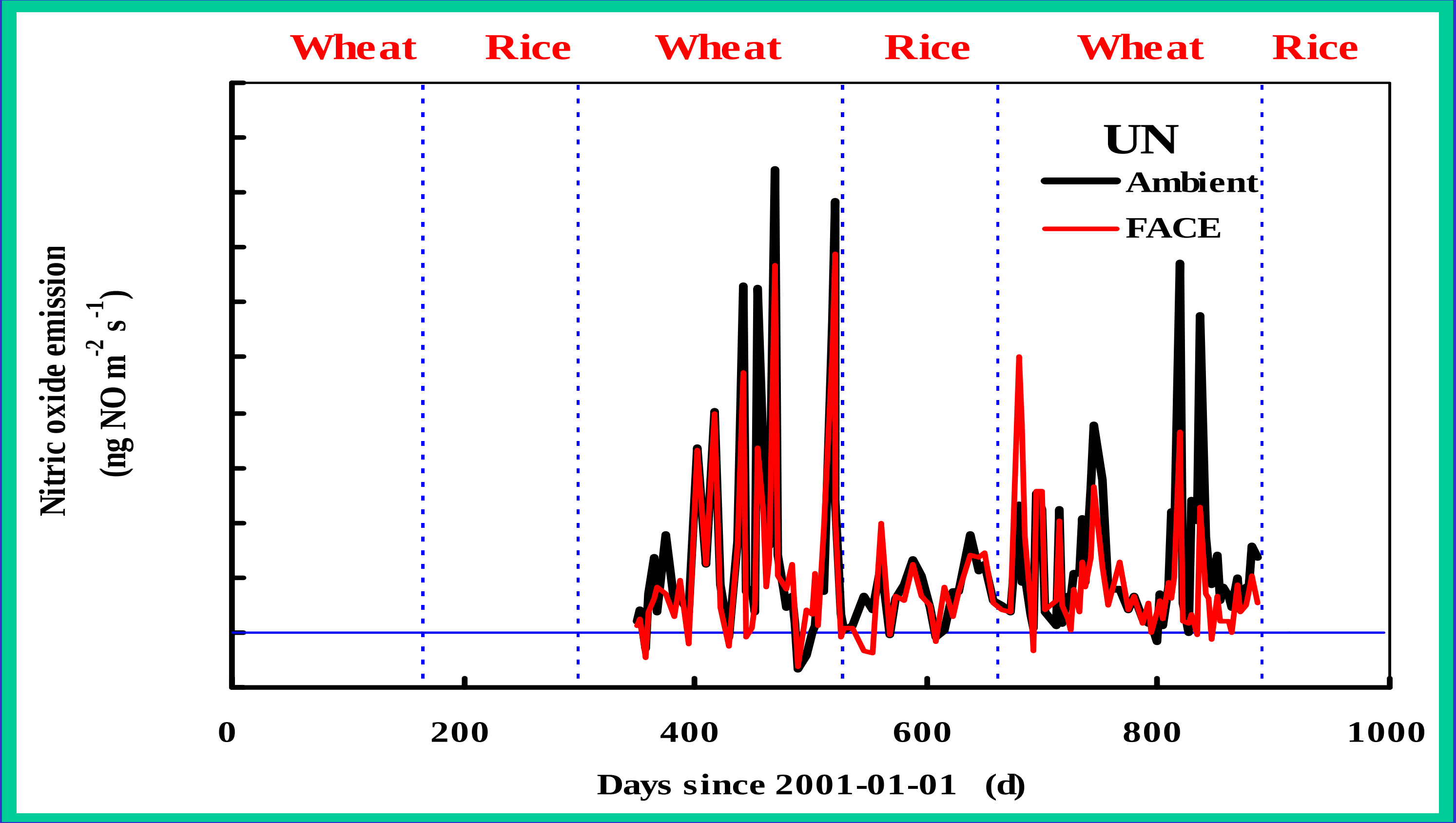
N_2O emission





Observed N_2O emission fluxes from rice-wheat rotation fields (2001. 6. 25 ~ 2003. 9. 29)

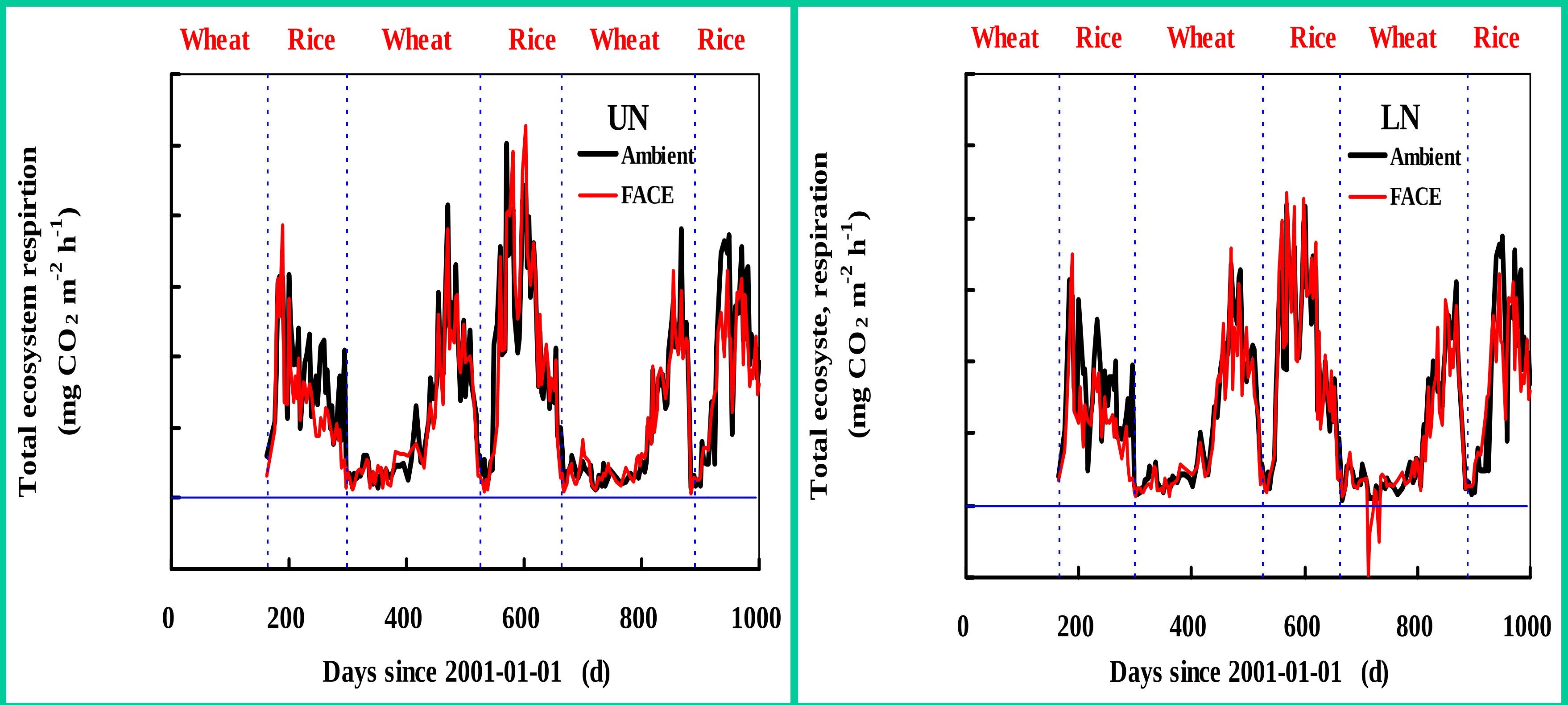
NO emission



Observed NO emission fluxes from rice-wheat rotation fields

(2001. 12. 16 ~ 2003. 6. 5)

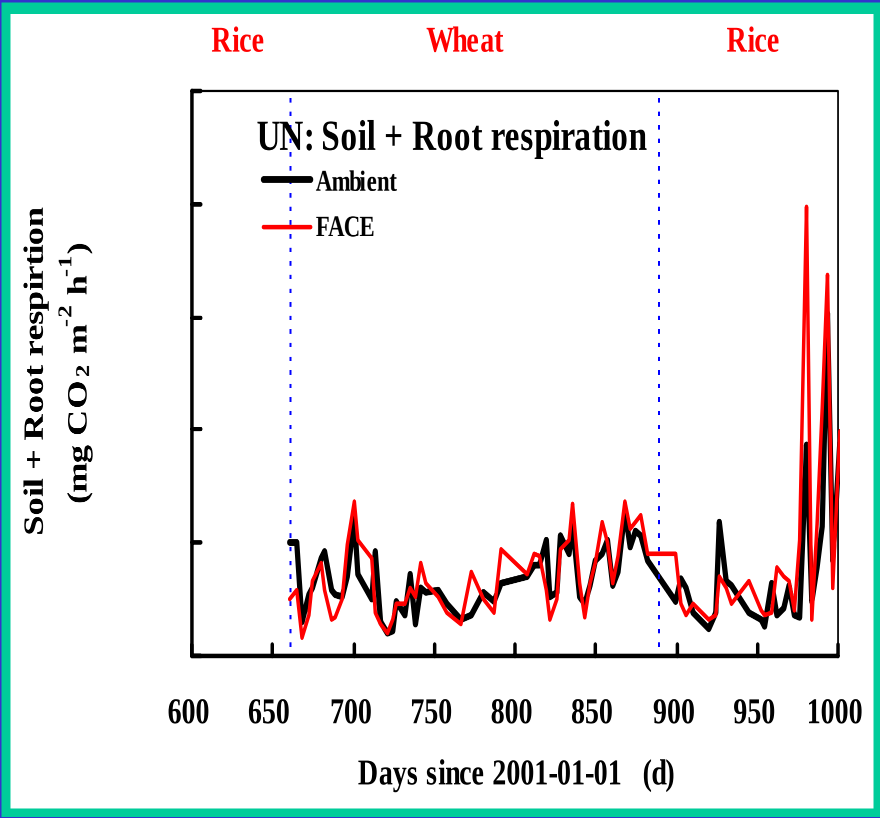
CO_2 emission due to total ecosystem respiration (TER)

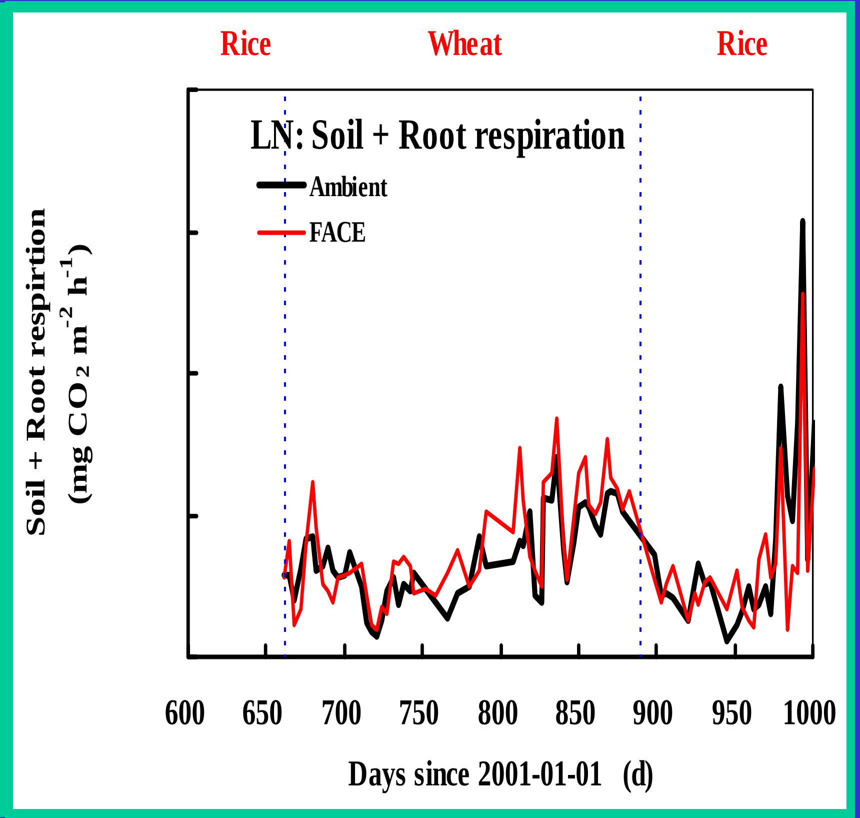


Observed CO_2 emission fluxes of TER from rice-wheat rotation fields

（2001. 6. 25 ~ 2003. 9. 29）

CO_2 emission due to soil respiration (Rs)

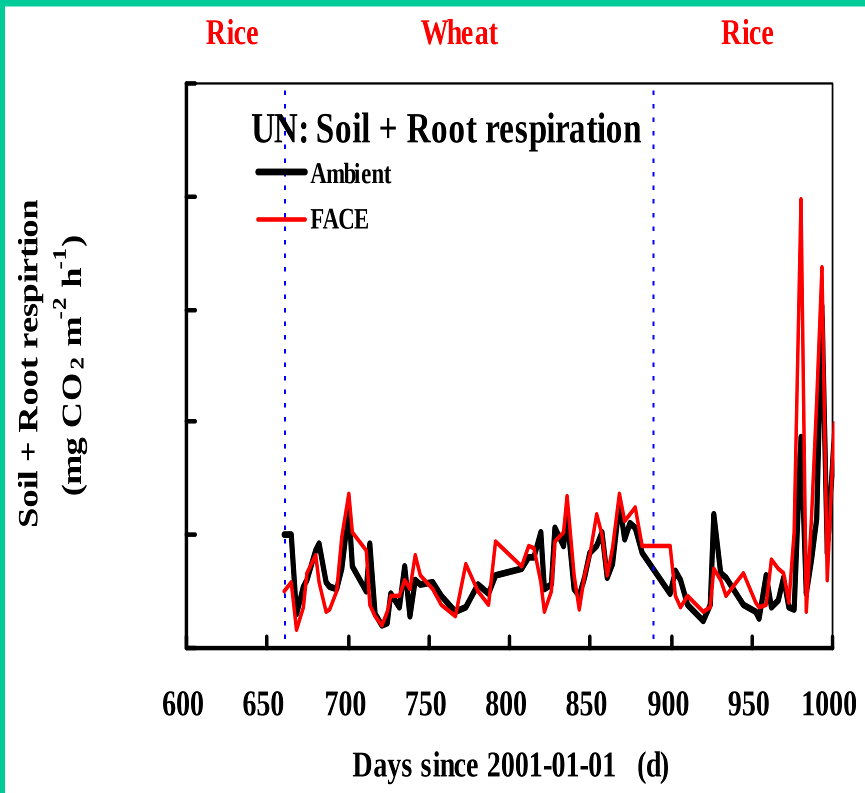


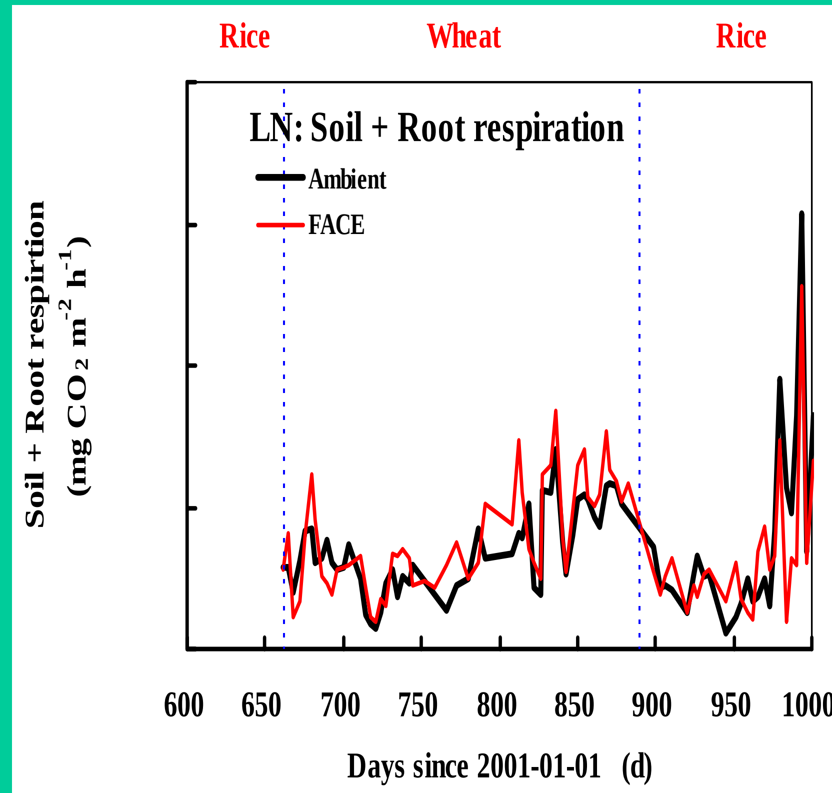


Observed CO_2 emission fluxes of Rs from rice-wheat rotation fields

（2002. 10. 28 ~ 2003. 9. 29）

CO_2 emission due to soil heterotrophic respiration (Rh)

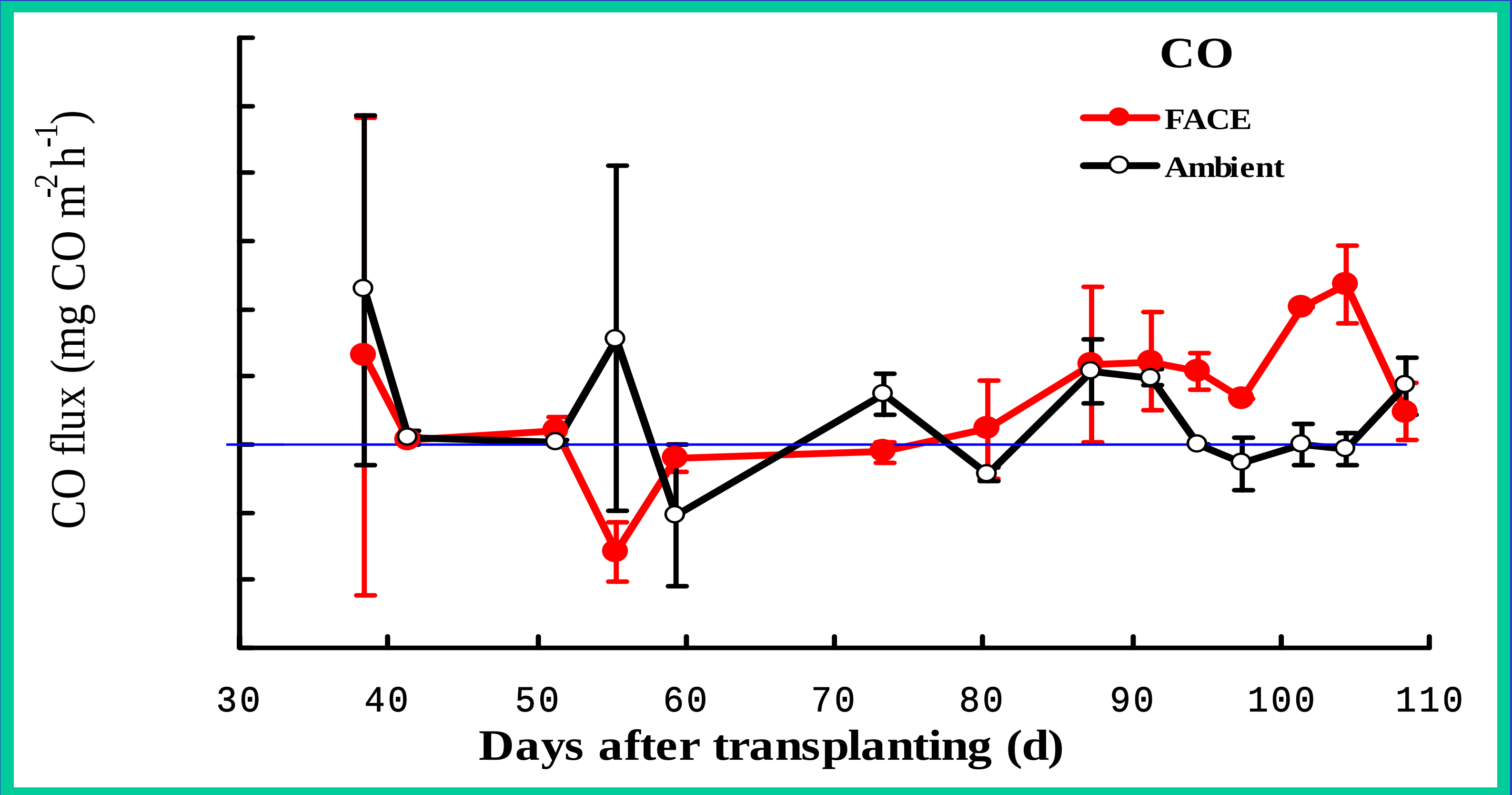




Observed CO_2 emission fluxes of Rh from rice-wheat rotation fields

(2002. 10. 28 ~ 2003. 9. 29)

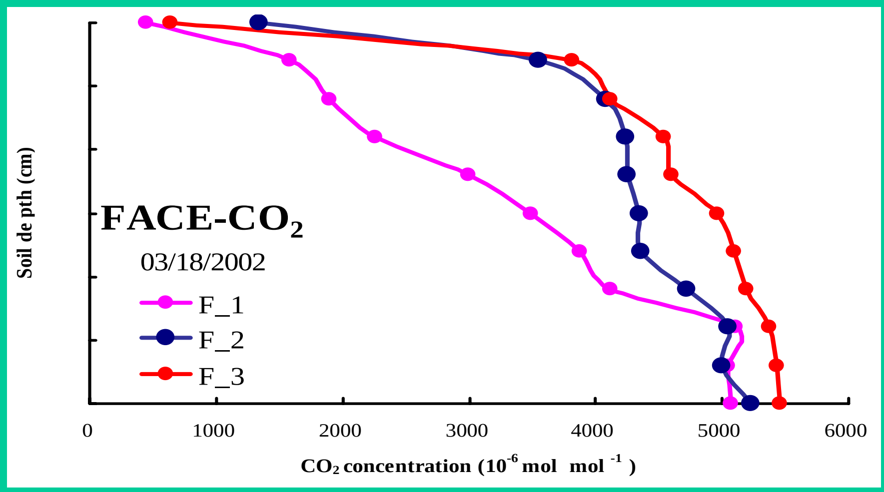
CO emission

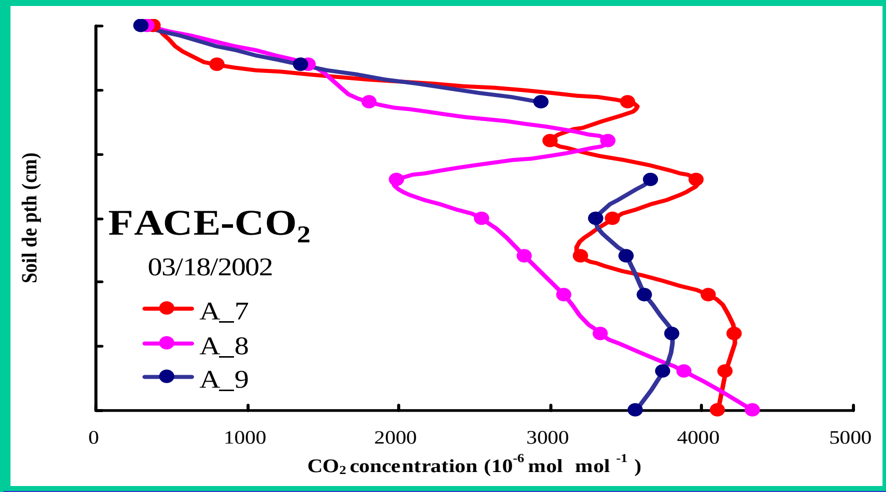


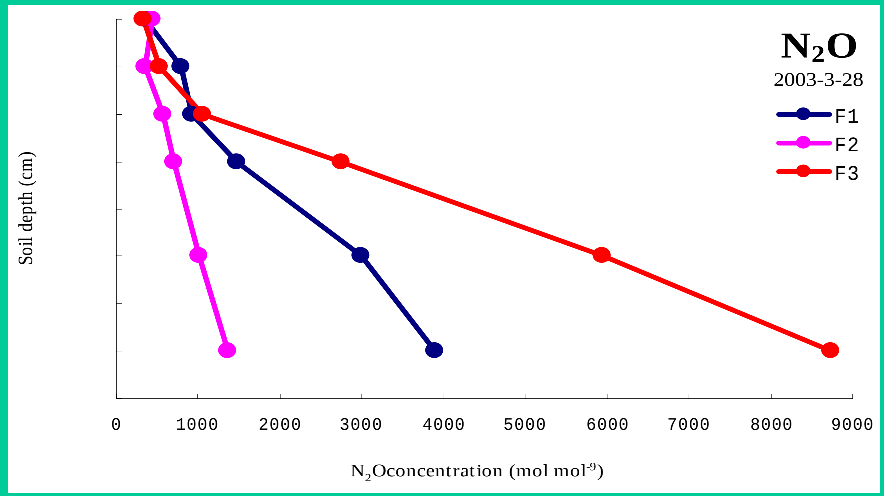
Observed CO_2 emission fluxes during the paddy rice season

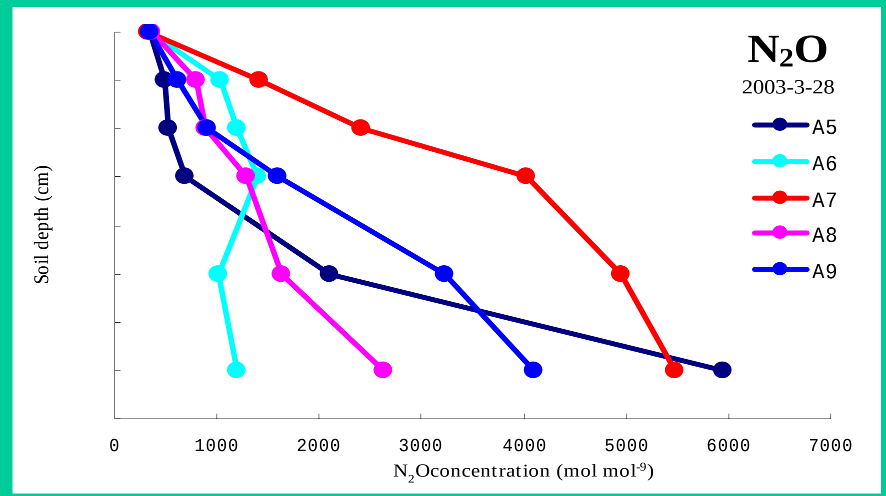
(2003. 7. 21 ~ 9. 29)

Soil CO_2 and N_2O concentration profiles P.1



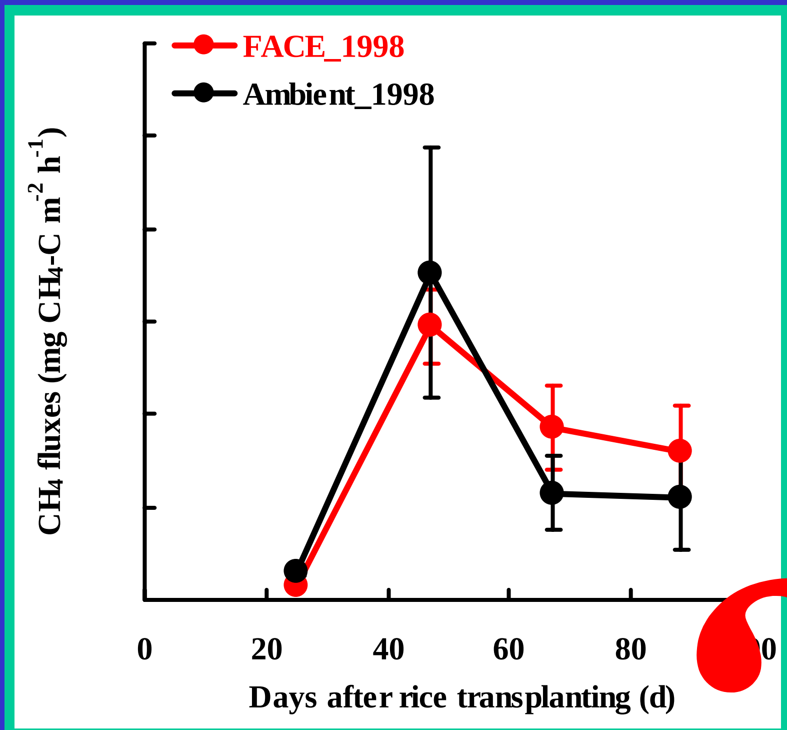


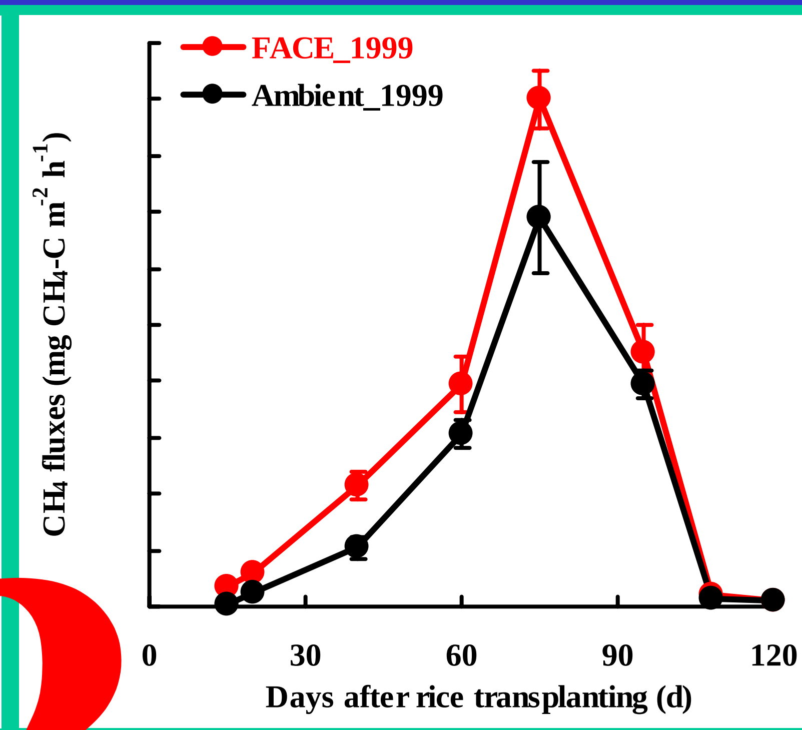




Observed CO_2 and N_2O profiles during upland period

Previous knowledge on FACE effects on CH_4 emission from paddy rice fields



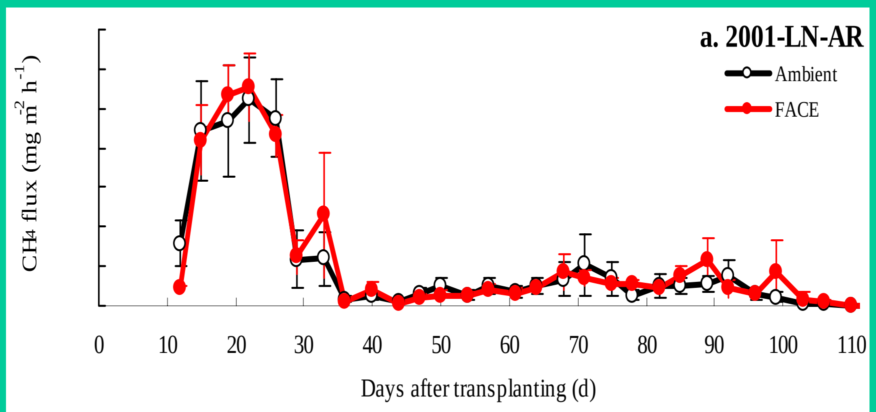


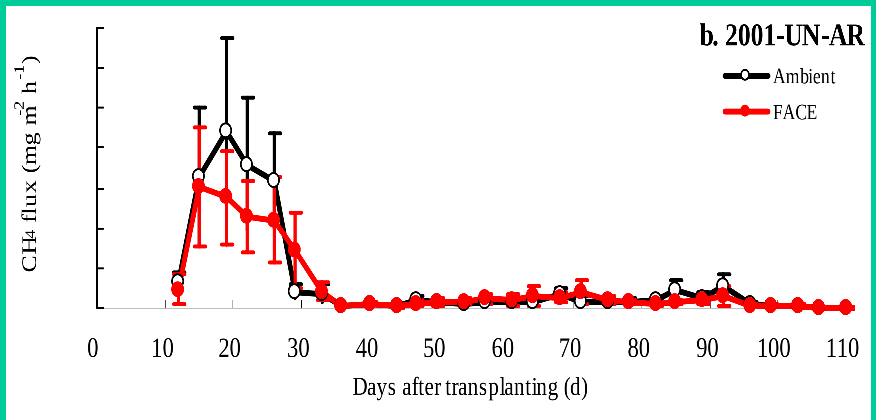
1st year
5%， p = 0.7

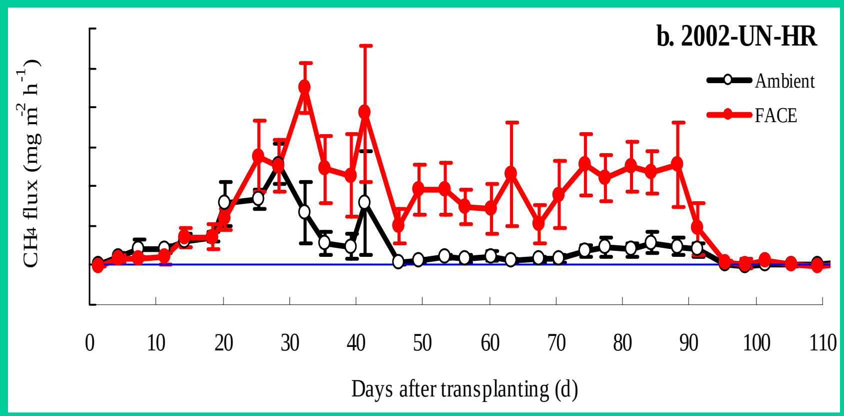
1st year
34%， p = 0.03

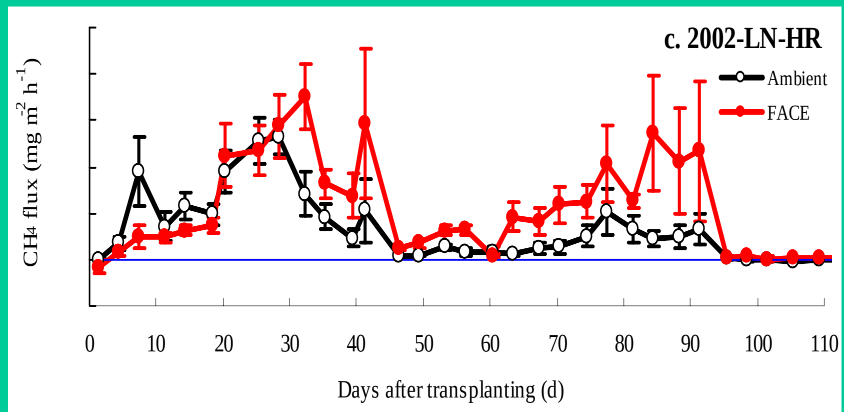
Observed in Japan (Inubushi et al., 2002)

FACE effect on CH_4 emission in the 1st and 2nd year after suddenly CO_2 elevation

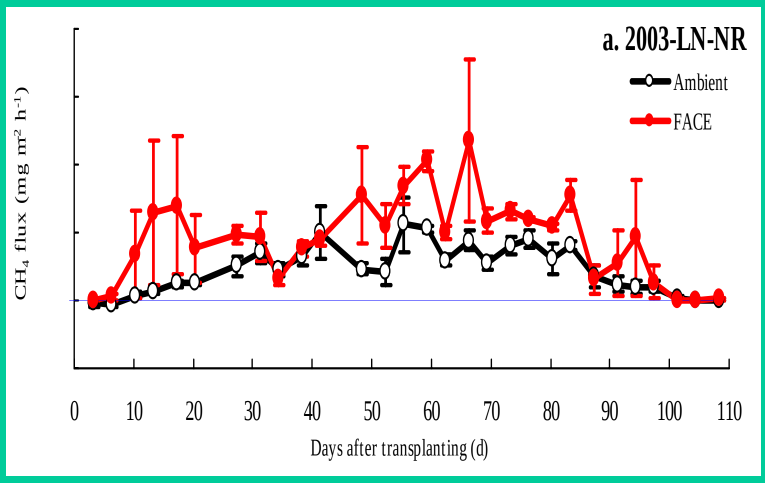


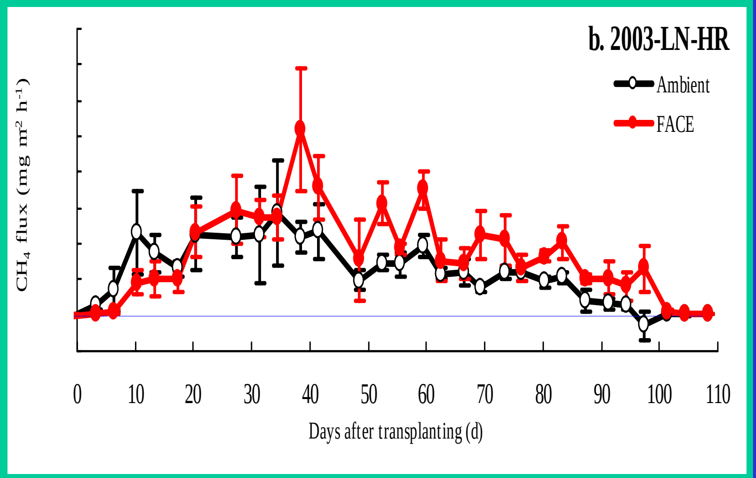


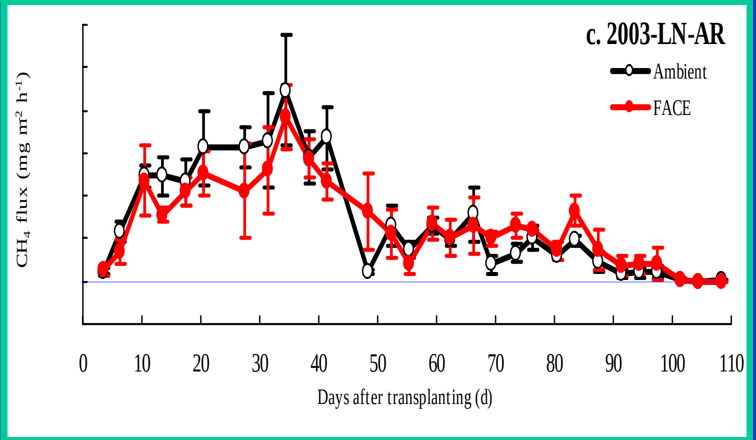


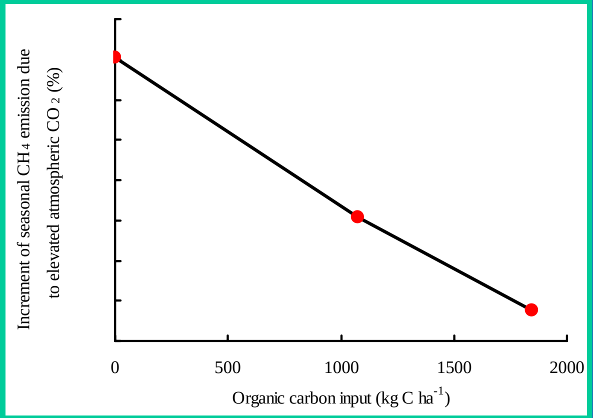


FACE effect on CH_4 emission in the 3rd year after suddenly CO_2 elevation

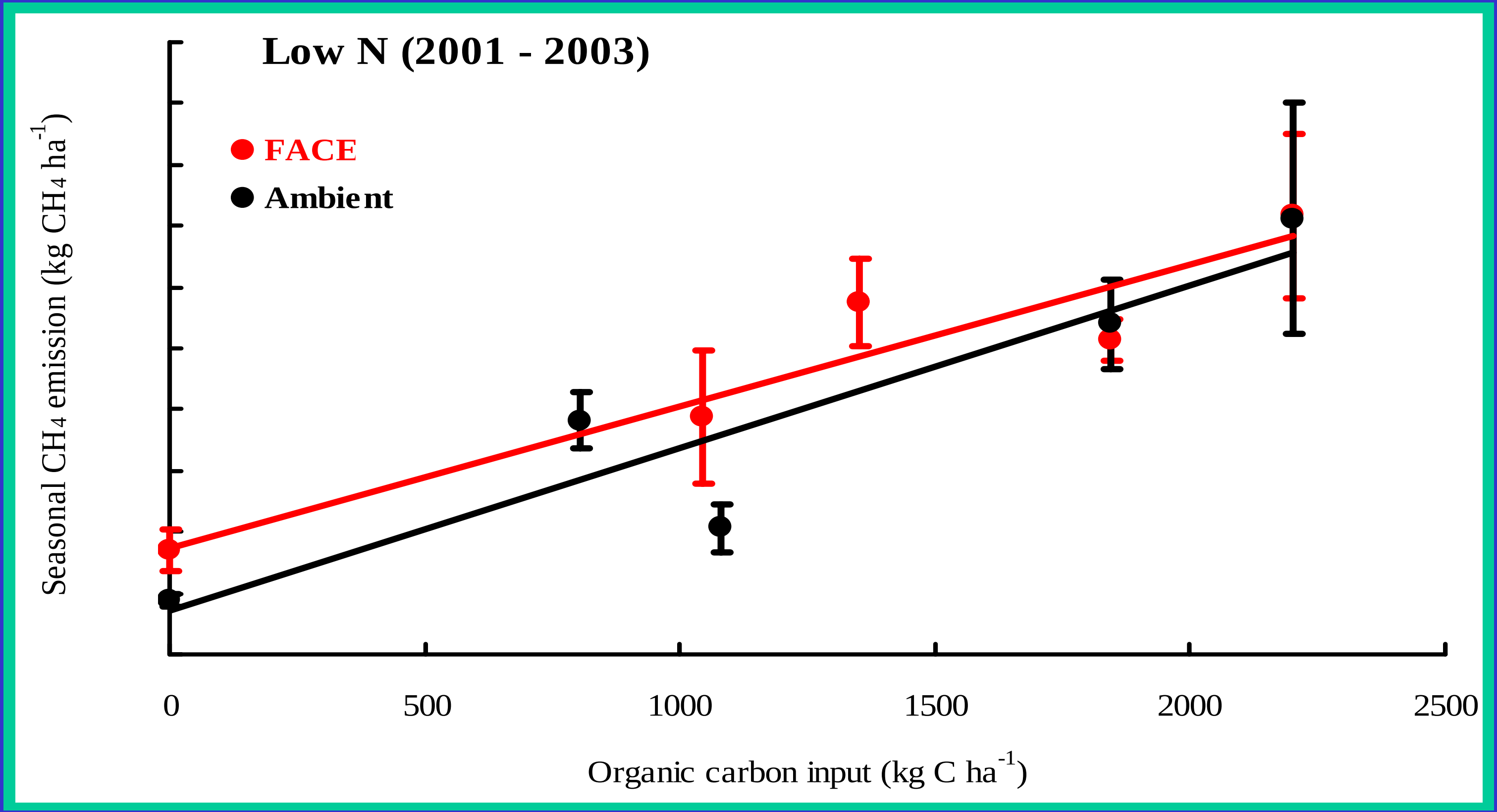






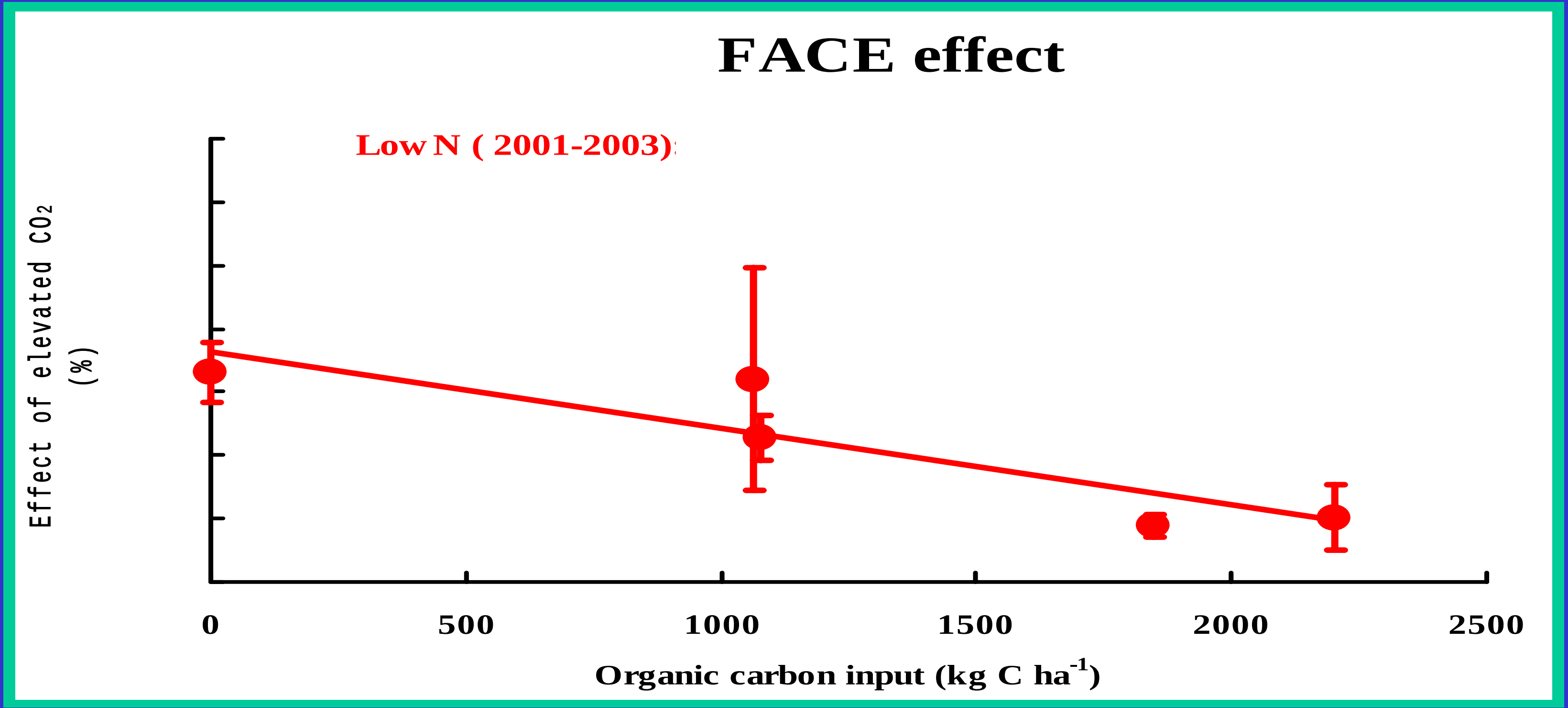


FACE effect on CH_4 emission



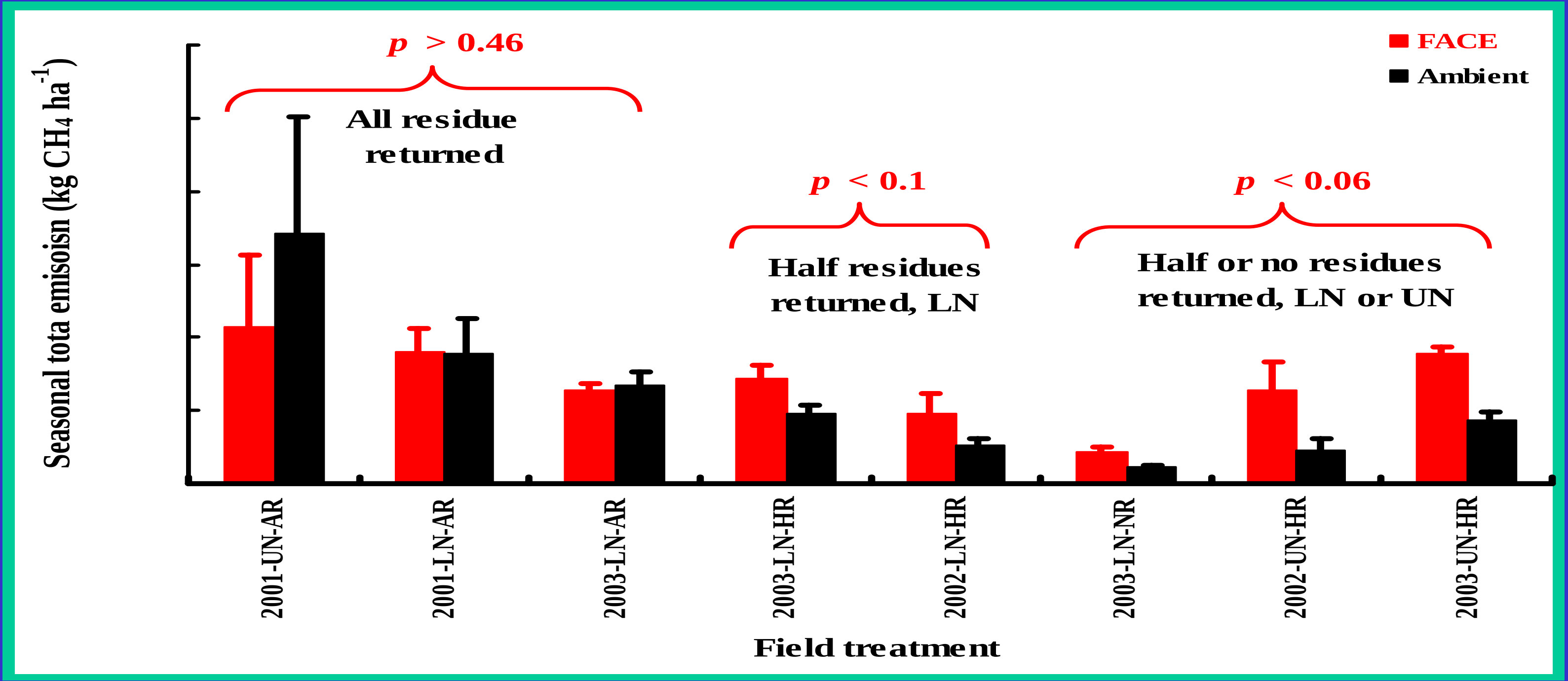
Seasonal total CH_4 emission increases versus organic carbon input at a higher rate under Ambient than under FACE condition .

FACE effect on CH_4 emission



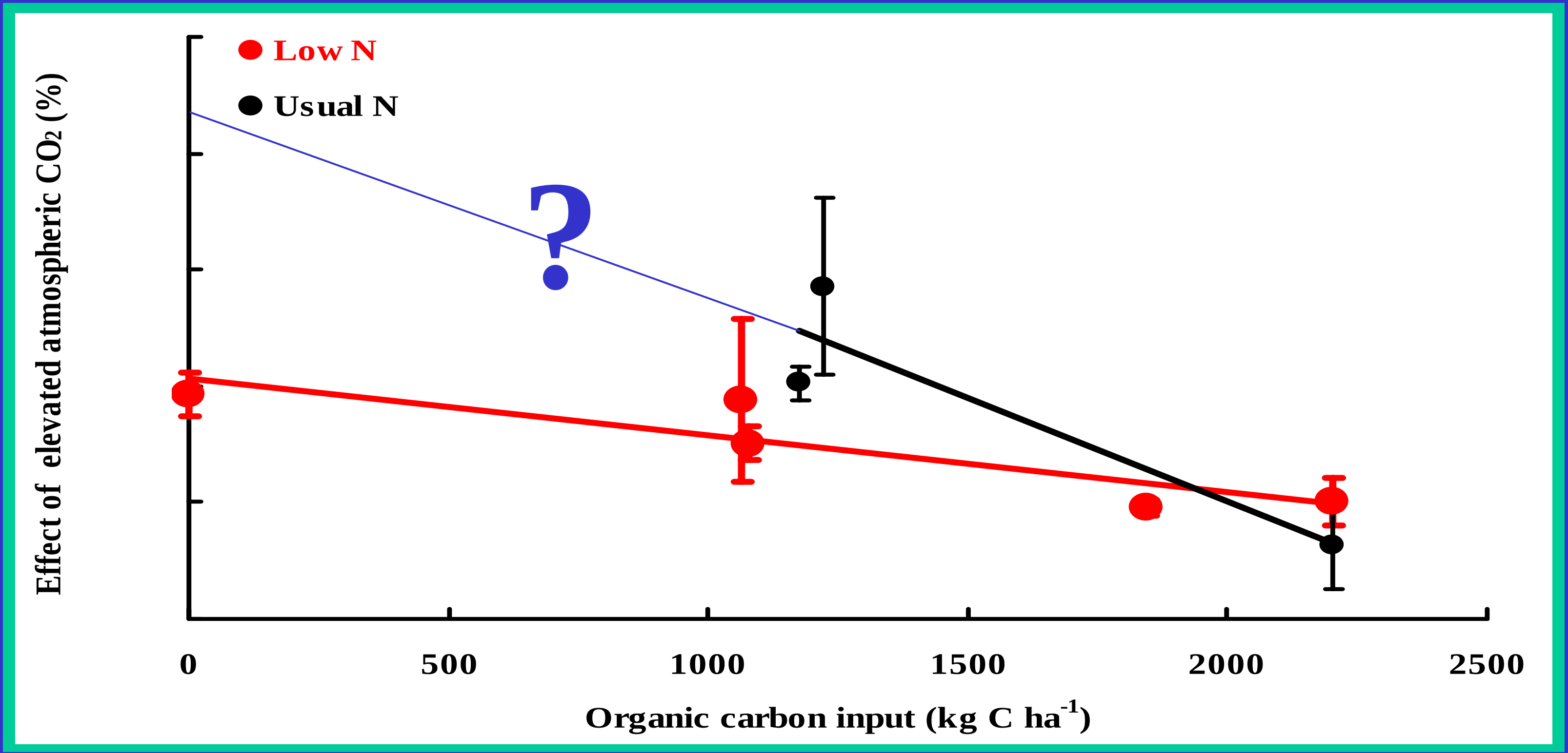
At a low N application rate, the effect of elevated CO_2 on seasonal CH_4 emission negatively correlated with organic carbon application rate, which could be described with a linear function.

FACE effect on CH_4 emission



The significant level of FACE effect on CH_4 emission is not only associated with organic carbon application rate, but also associated with the level of fertilizer nitrogen application.

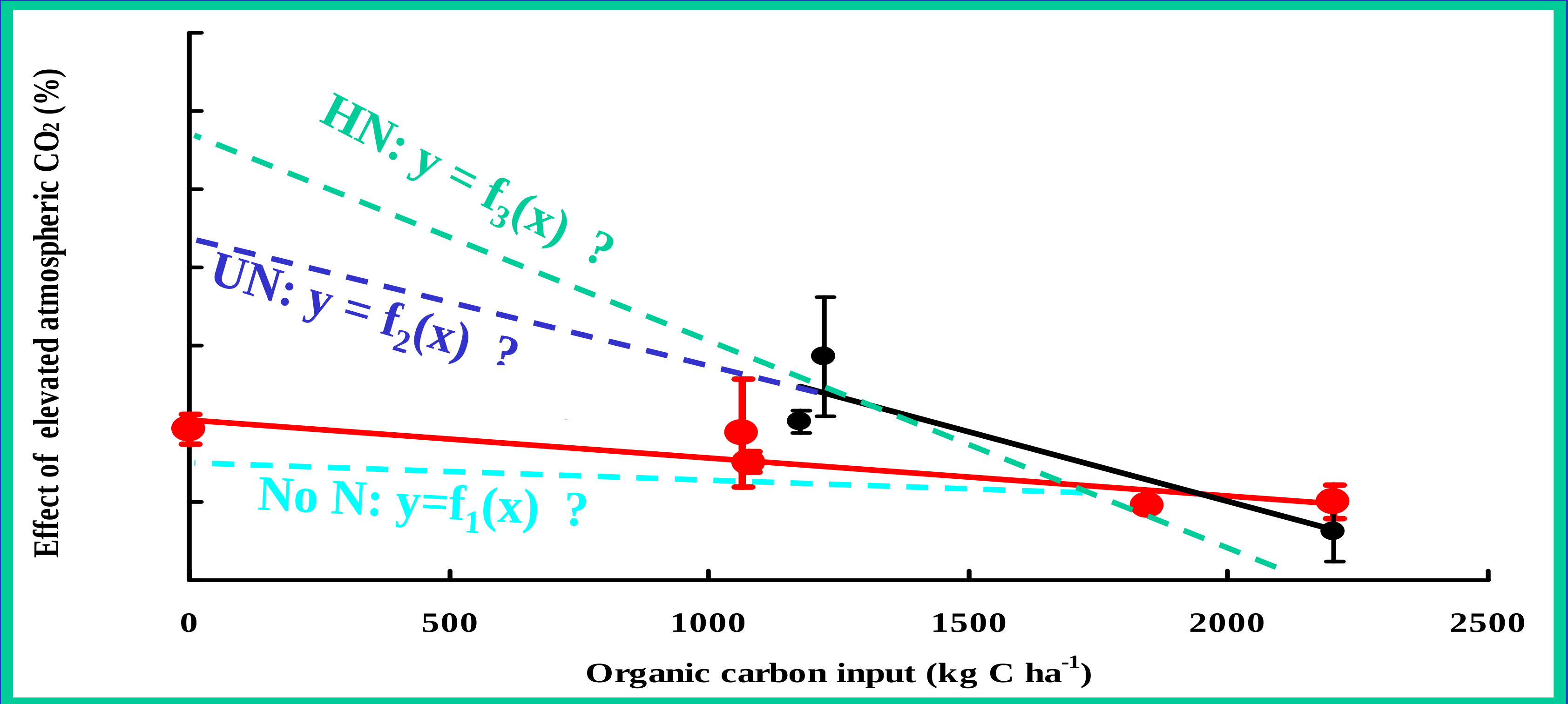
FACE effect on CH_4 emission



At a usual nitrogen application rate, does the FACE effect on CH_4 emission also linearly vary versus organic carbon application rate?

No clear, yet!

FACE effect on CH_4 emission



Assuming the dashed lines for No N, UN and HN (high N) are true, then a function, with the N and C application rates being the independent variables, might be established:

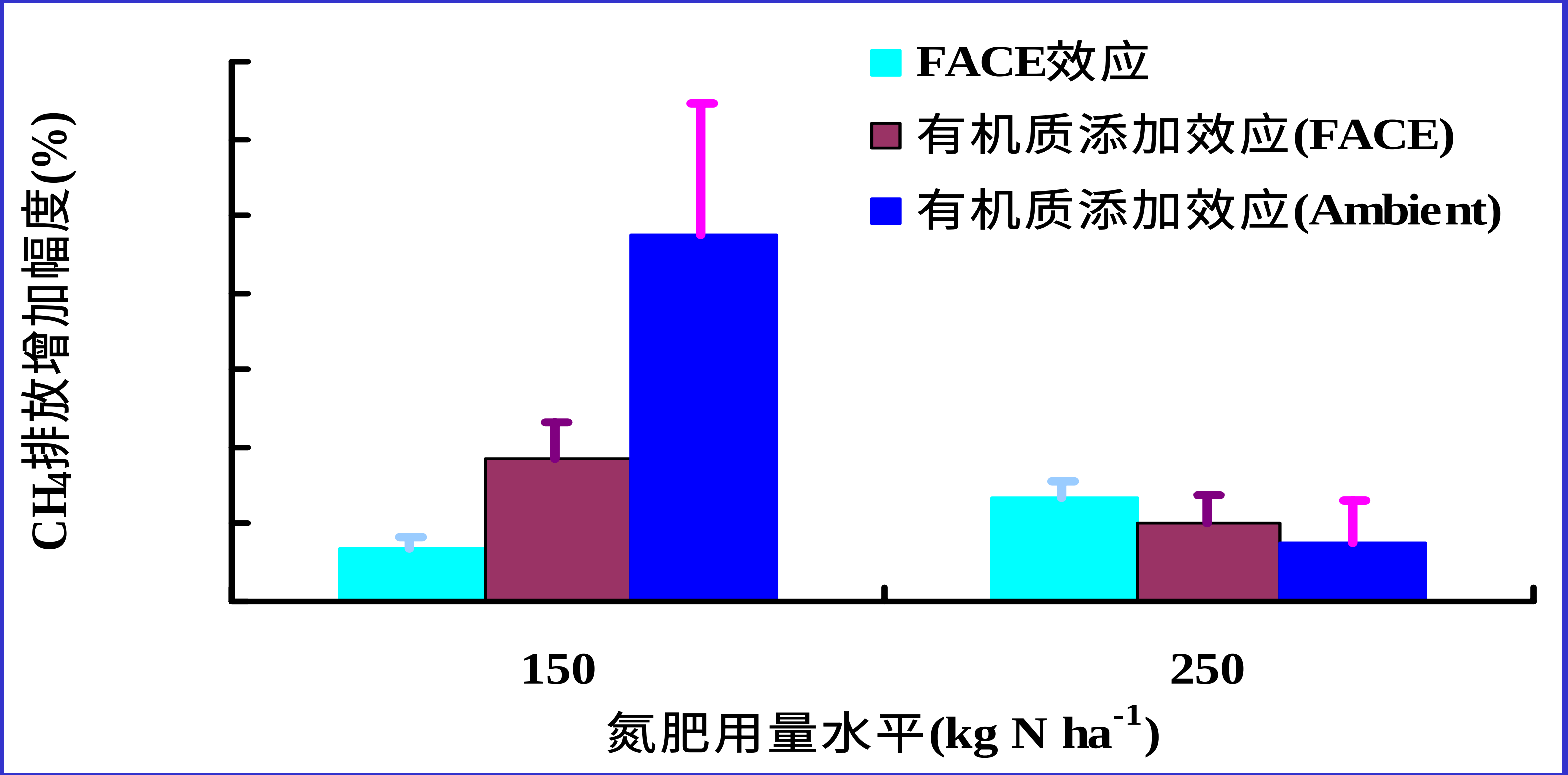
$$FE_{200} = -0.0004N \cdot C - 0.037C + 0.0015N^2 + 0.57N + 24.5$$

FACE effect on CH_4 emission

Effect (%)	Organic carbon (kg C ha^{-1})															
Fertilizer N (kg N ha^{-1})	0	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000
0	25	17	10	3	-5	-12	-19	-27	-34	-41	-49	-56	-63	-71	-78	-85
20	36	27	19	10	1	-8	-17	-26	-35	-44	-53	-62	-71	-80	-88	-97
40	50	39	28	18	7	-3	-14	-24	-35	-45	-56	-66	-77	-87	-98	-108
60	64	52	40	27	15	3	-9	-21	-33	-45	-57	-70	-82	-94	-106	-118
80	79	66	52	38	24	11	-3	-17	-30	-44	-58	-72	-85	-99	-113	-126
100	96	81	65	50	35	19	4	-11	-27	-42	-57	-73	-88	-103	-118	-134
120	114	97	80	63	46	29	12	-5	-21	-38	-55	-72	-89	-106	-123	-140
140	133	114	96	77	59	40	22	3	-15	-34	-52	-71	-89	-108	-126	-145
160	153	133	113	93	73	53	33	12	-8	-28	-48	-68	-88	-108	-128	-148
180	175	153	131	110	88	66	44	23	1	-21	-42	-64	-86	-108	-129	-151
200	198	174	151	128	104	81	58	34	11	-12	-36	-59	-82	-106	-129	-152
220	221	196	172	147	122	97	72	47	22	-3	-28	-53	-78	-103	-127	-152
240	247	220	193	167	140	114	87	61	34	8	-19	-45	-72	-98	-125	-151
260	273	245	217	188	160	132	104	76	48	20	-8	-37	-65	-93	-121	-149
280	300	271	241	211	181	152	122	92	63	33	3	-27	-56	-86	-116	-145
300	329	298	266	235	204	172	141	110	78	47	16	-16	-47	-78	-109	-141

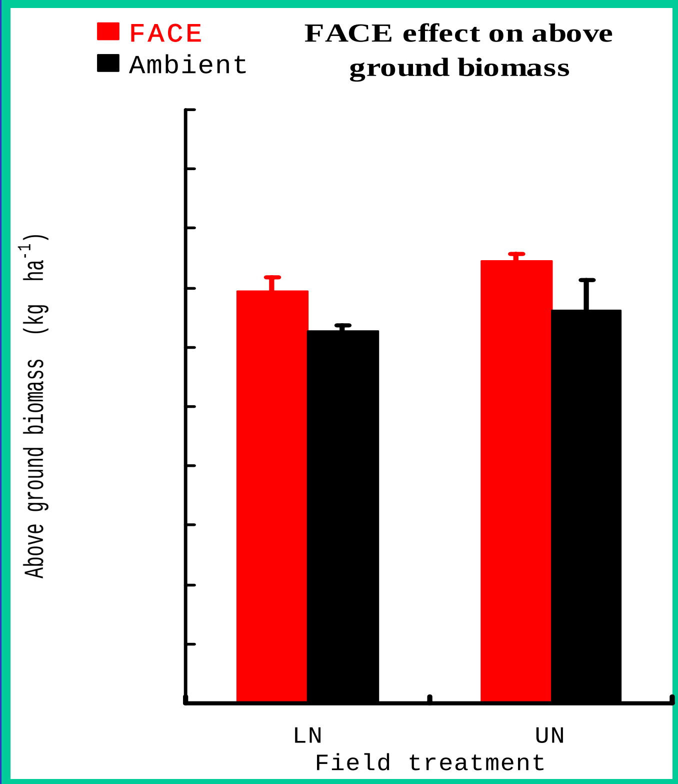
The FACE effect on CH_4 emission from rice paddy fields might be positively up to 300% or negatively down to -150%, depending upon the combination of N and C application.

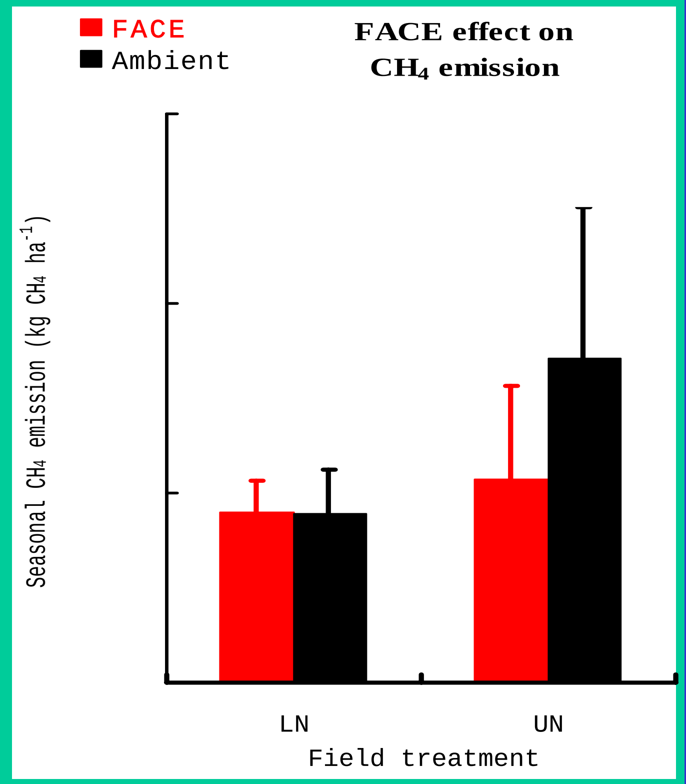
FACE effect on CH_4 emission



Under the high organic C application level, the effects of organic C supplies on CH_4 emission usually override the FACE effects. The overriding effects are especially more obvious when N supplies are limited.

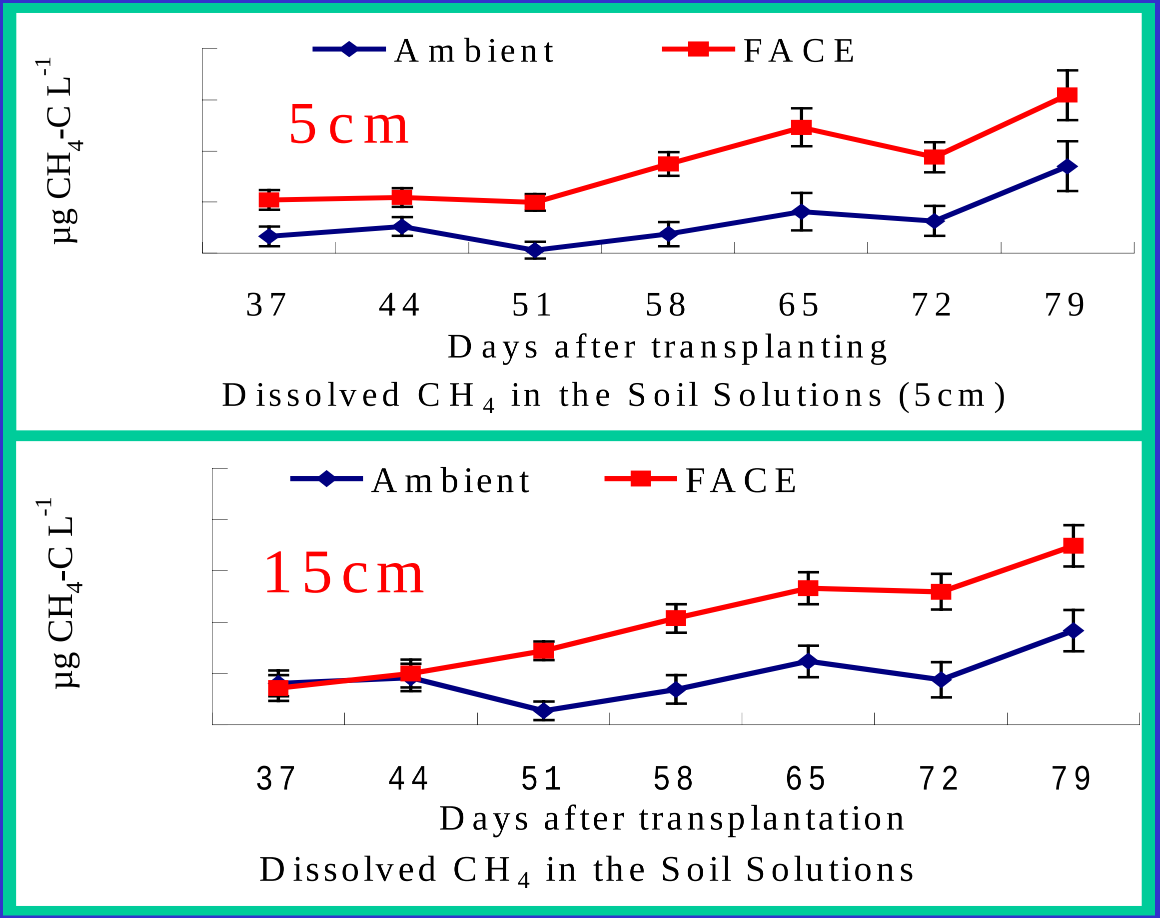
FACE effect on CH_4 emission





The vascular transportation capacity of transferring CH_4 from under ground to the atmosphere through rice plants is not enhanced due to elevated CO_2.

FACE effect on CH_4 emission



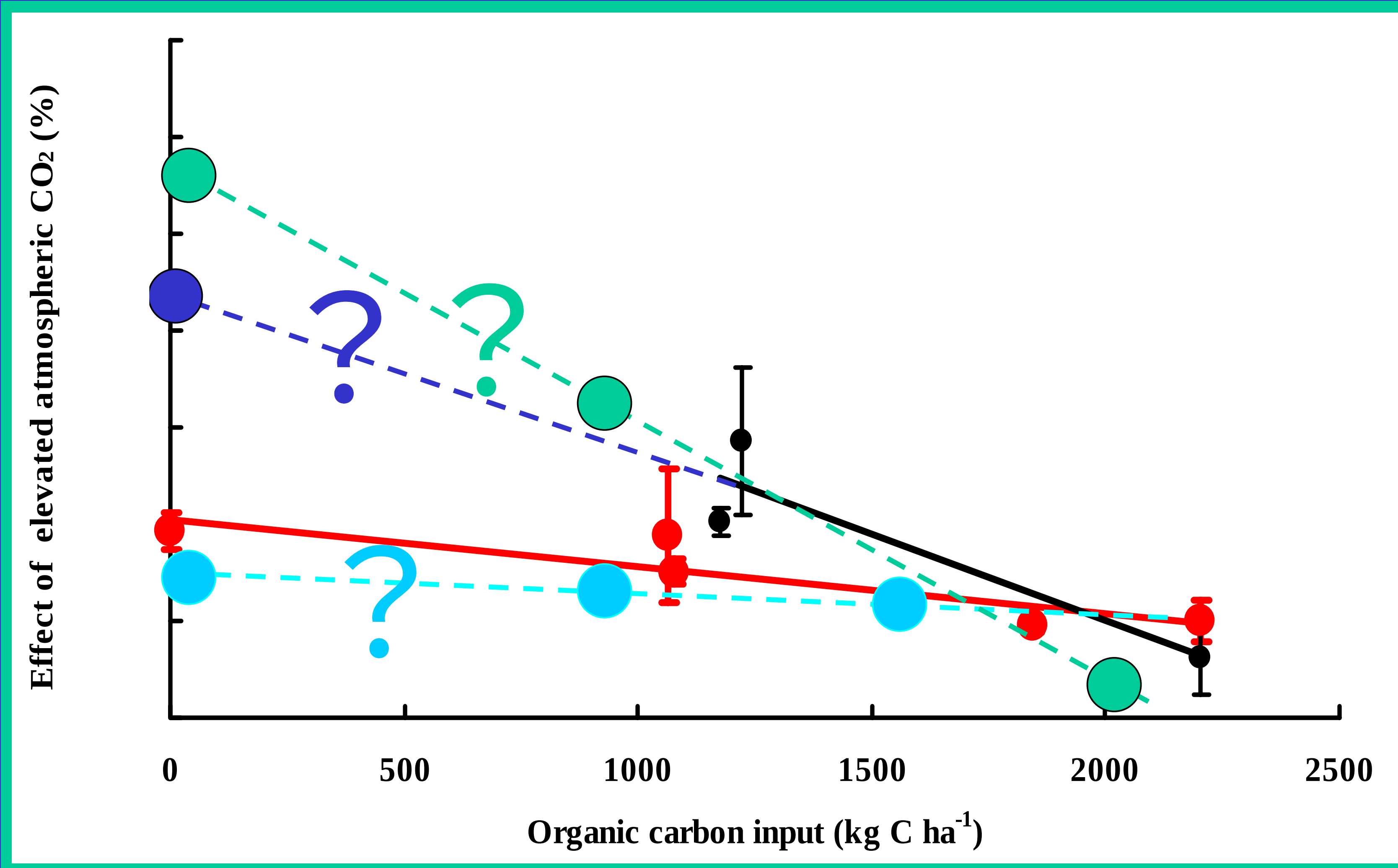
These two figures are provided by Jianguo Zhu and Zubin Xie (Institute of Soil Sciences, CAS)

CH_4 production is stimulated due to positive FACE effects on root production and exudation.

FACE effect on CH_4 emission

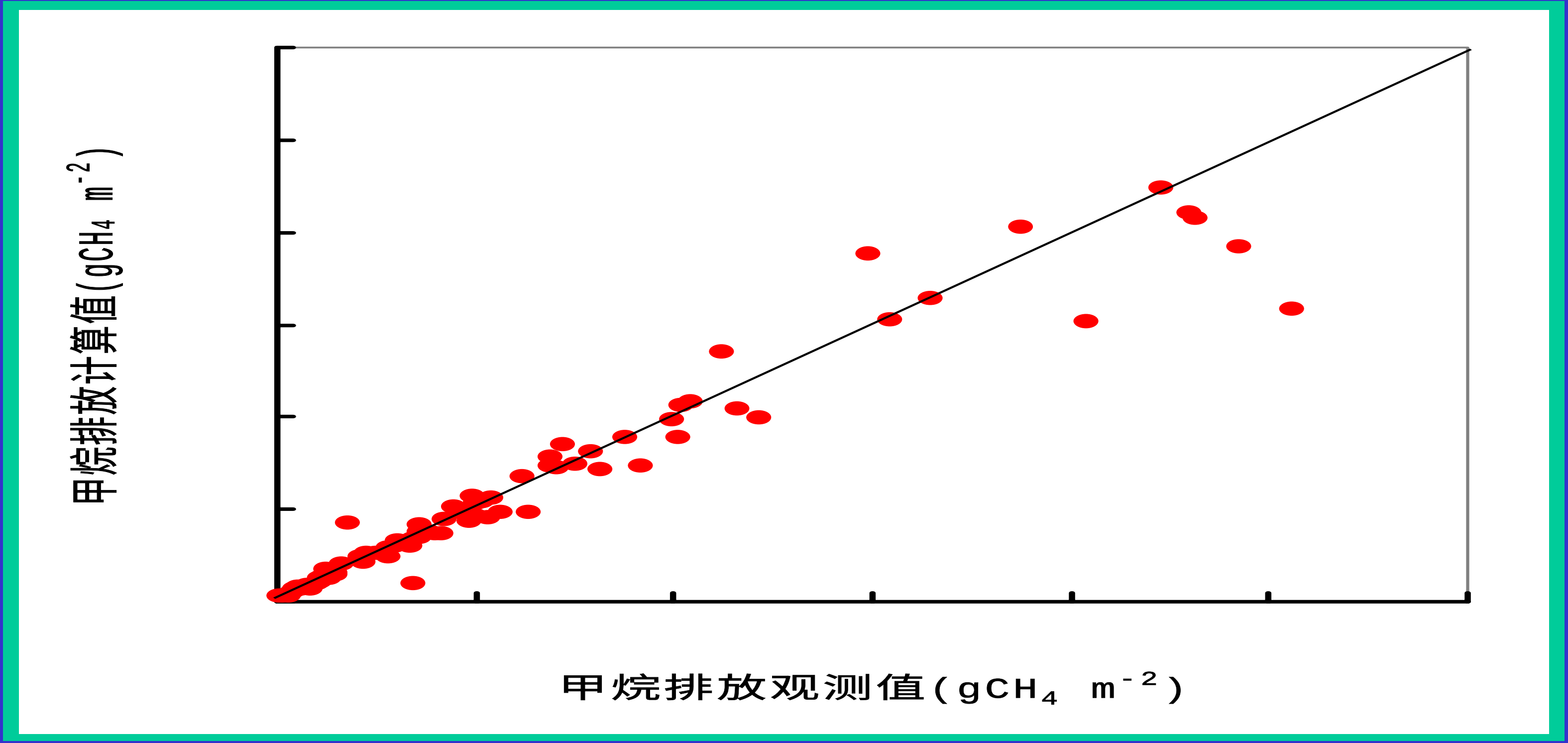
Mechanically, the positive FACE effect on CH_4 emission is mainly due to enhancement of root production and exudation. Vascular transportation is not important for the positive FACE effect on CH_4 emission from paddy rice fields.

FACE effect on CH_4 emission



Further study at the present experimental platform

FACE effect on CH_4 emission



Further study with modeling approaches:

Adapting available model to FACE conditions.

In summary

- **At a low level of N application, the FACE effect on seasonal CH_4 emission is negatively and linearly correlated with organic carbon application rate.**
- **The significant level of FACE effect on CH_4 emission is associated with the level of fresh organic matter application as well as the level of fertilizer nitrogen application.**
- **The positive FACE effect on CH_4 emission is mainly due to enhancement of root production and exudation. Vascular transportation is not important for the positive FACE effect on CH_4 emission from paddy rice fields.**
- **Further experimental and modeling investigation on the FACE effects on CH_4 emission from paddy rice fields are expected.**

Thanks ！